Variability in stratospheric water, methane and temperatures observed in HALOE data

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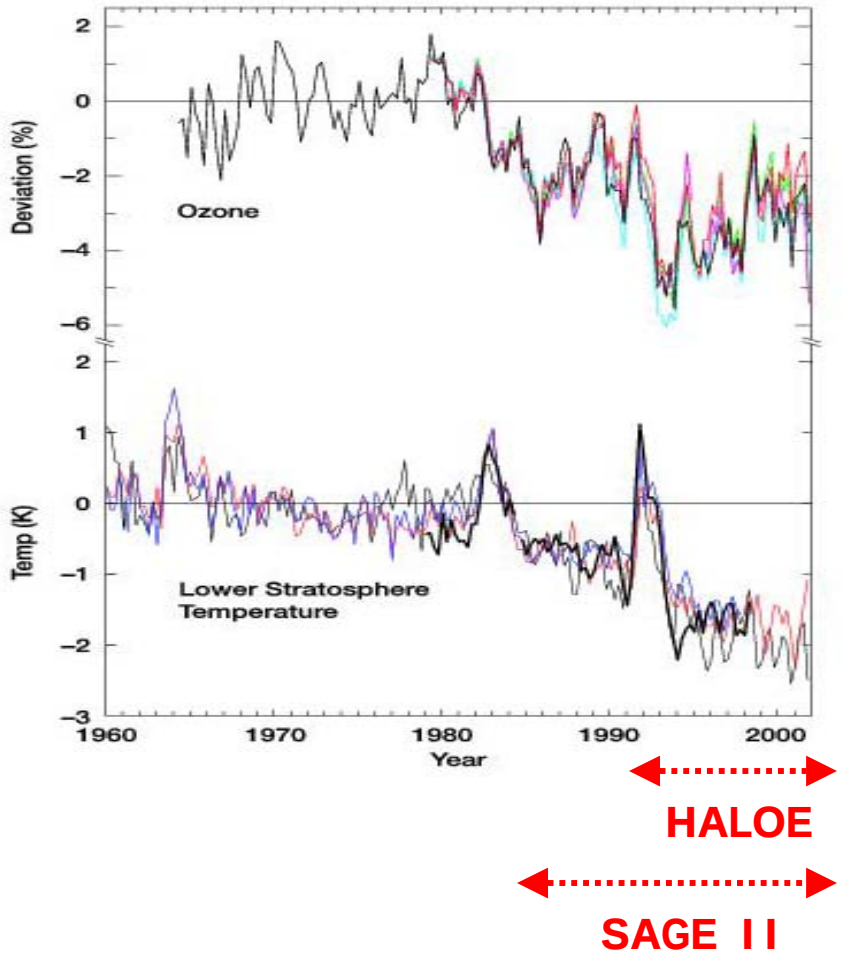
Context:



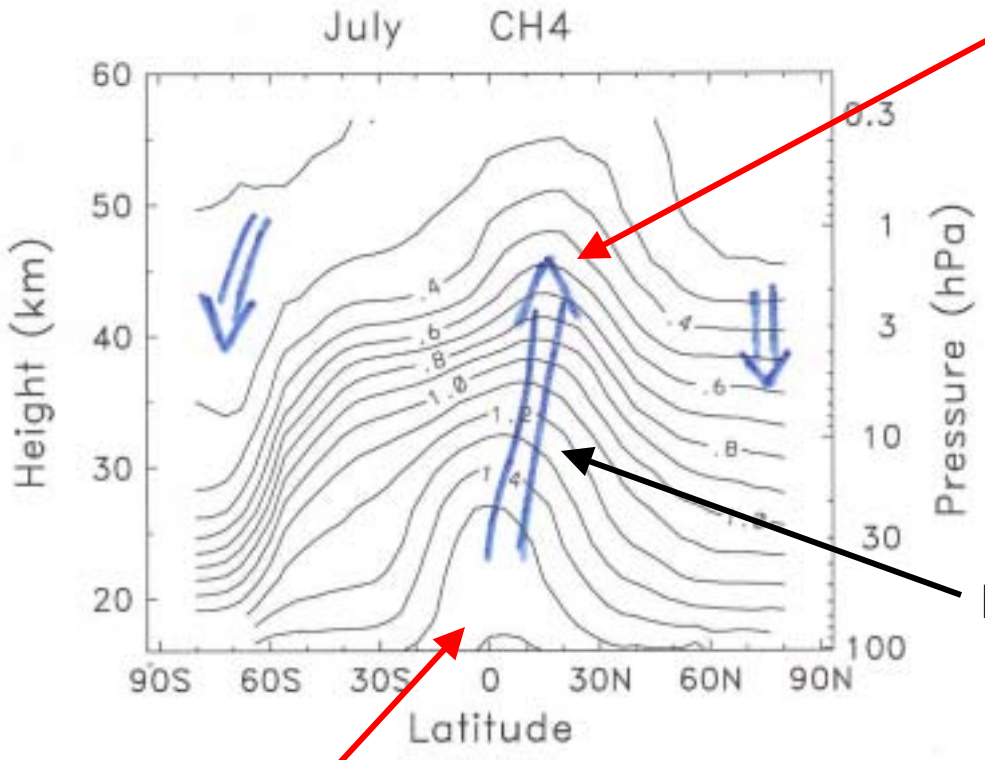
Global ozone decrease of ~ 3% since 1980

Cooling of lower stratosphere by ~1-2 K

This talk:

- methane changes
- HALOE temperatures
- stratospheric water vapor

Why is methane interesting?

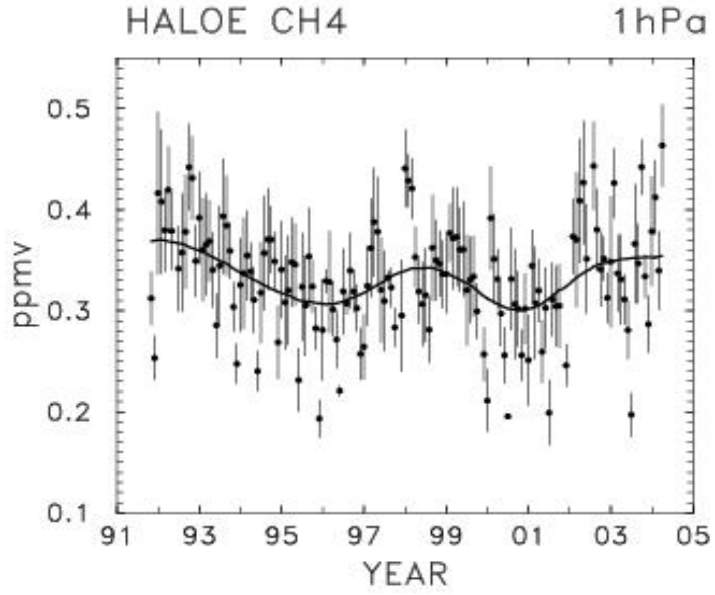


variations reflect transport (age of air)

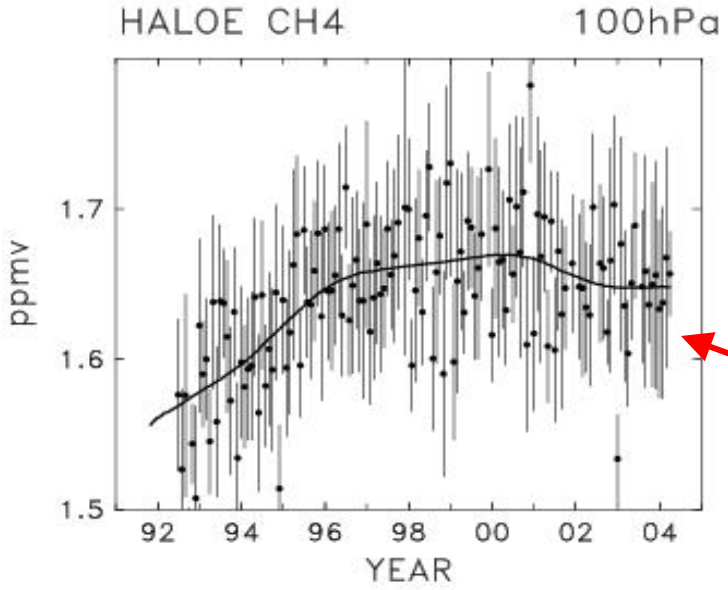
Brewer-Dobson circulation

variations reflect tropospheric source

HALOE methane



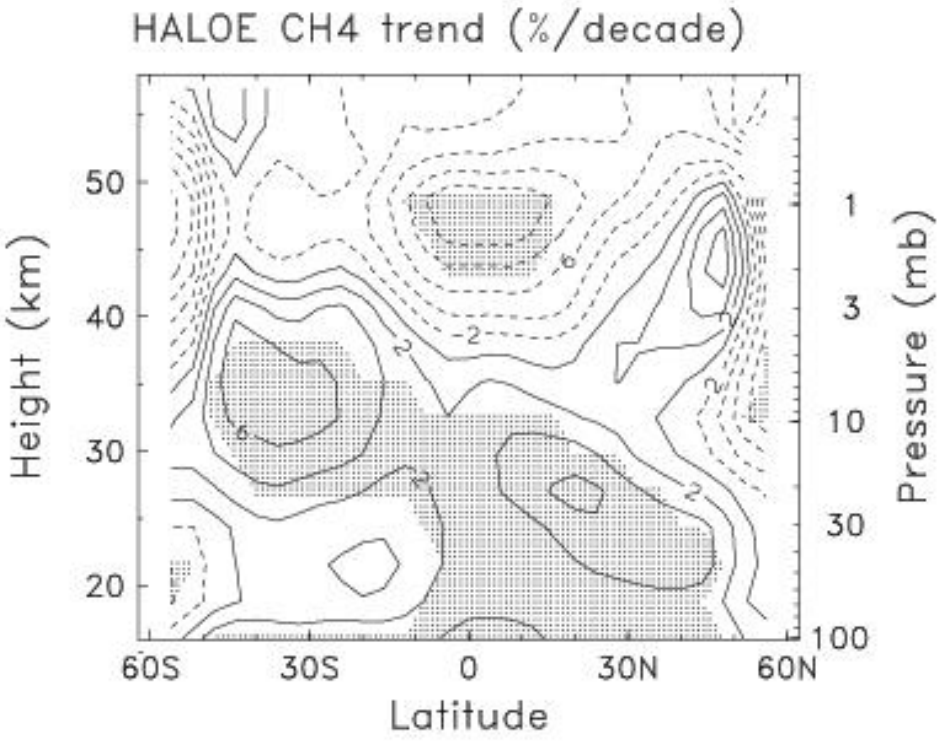
1 hPa



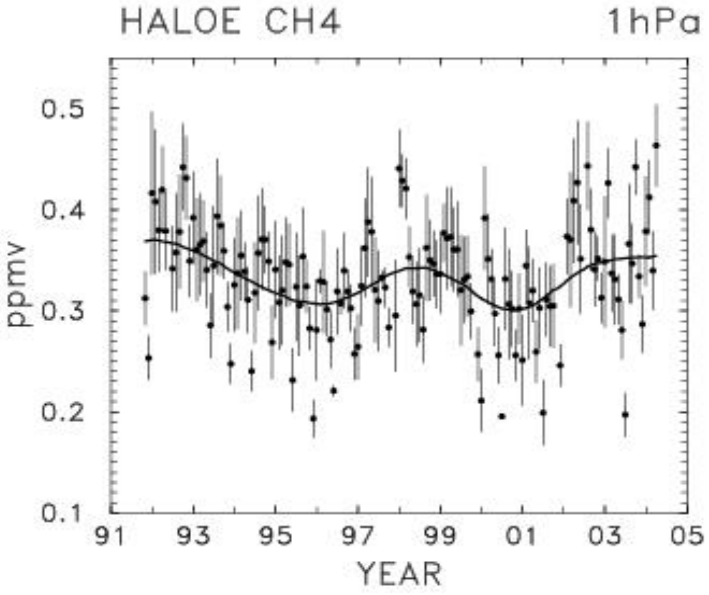
100 hPa

recent 'flattening' consistent with tropospheric CH4

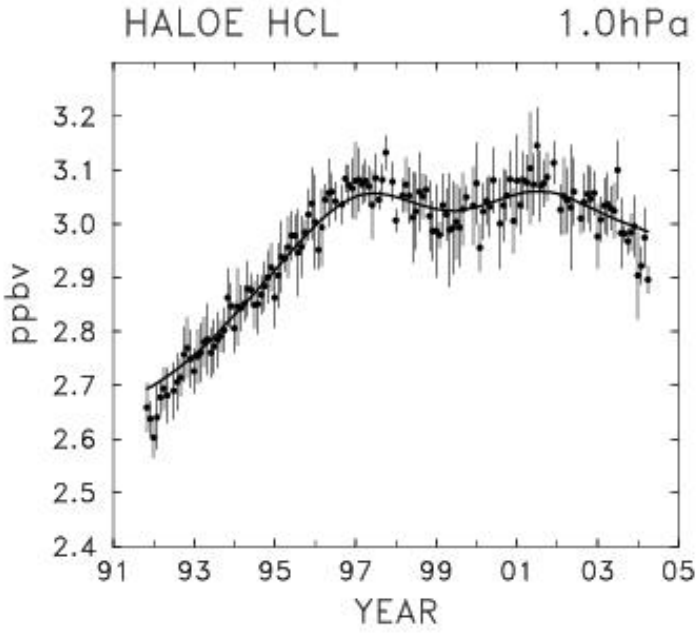
Methane ‘trends’ 1992-2003



Correlated changes in CH_4 and HCl



CH_4

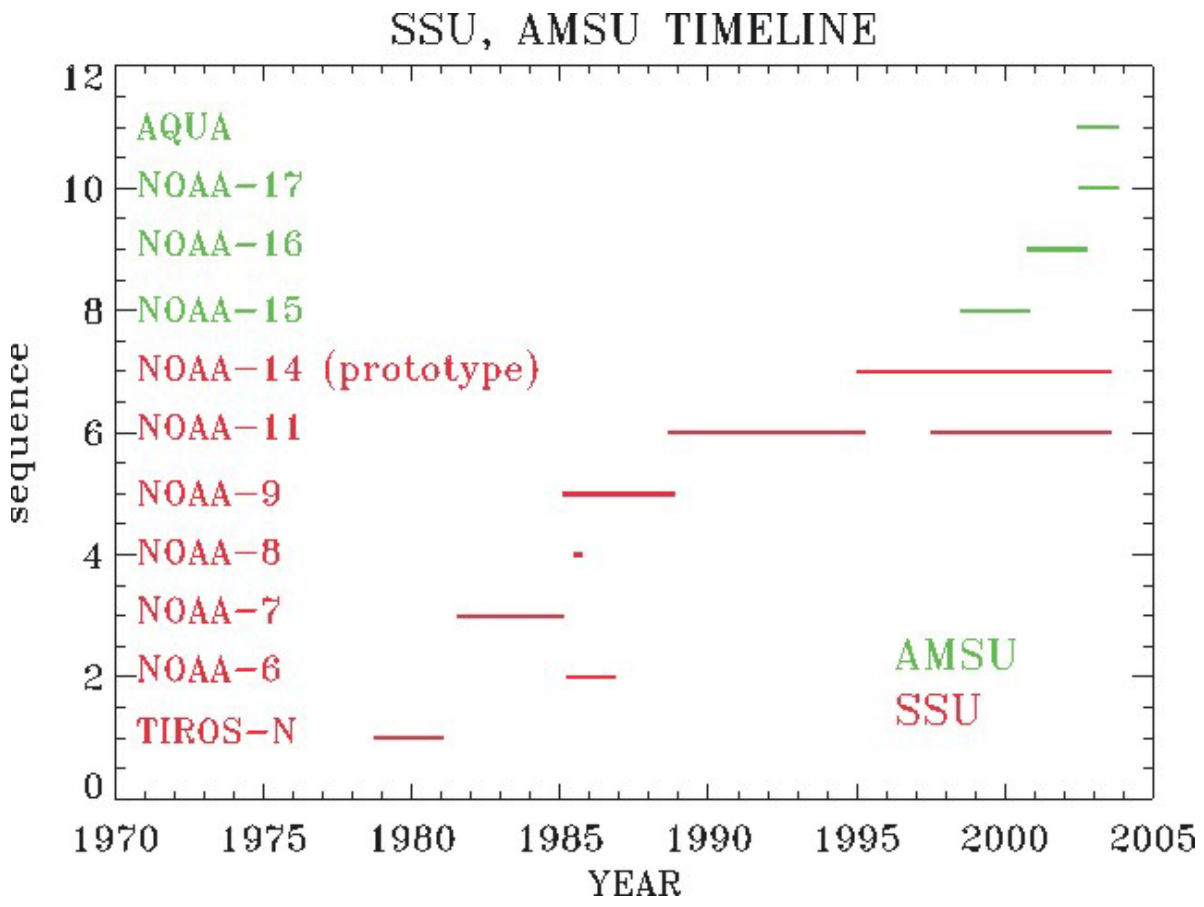


HCl

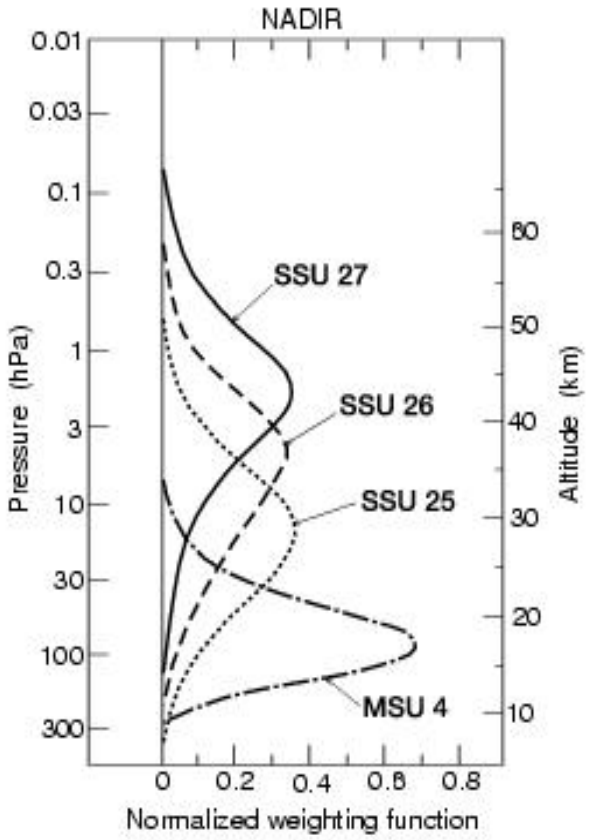
Upper stratospheric temperatures

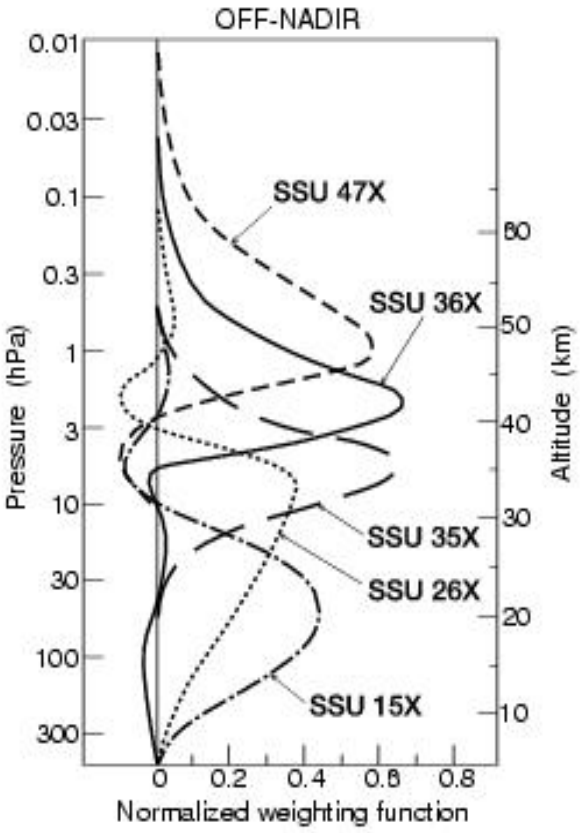
- Available data:
  - operational satellite data (SSU/MSU/AMSU)
  - meteorological analyses / reanalyses
  - lidars (few locations)
  - SAGE II and HALOE

data from NOAA operational satellites

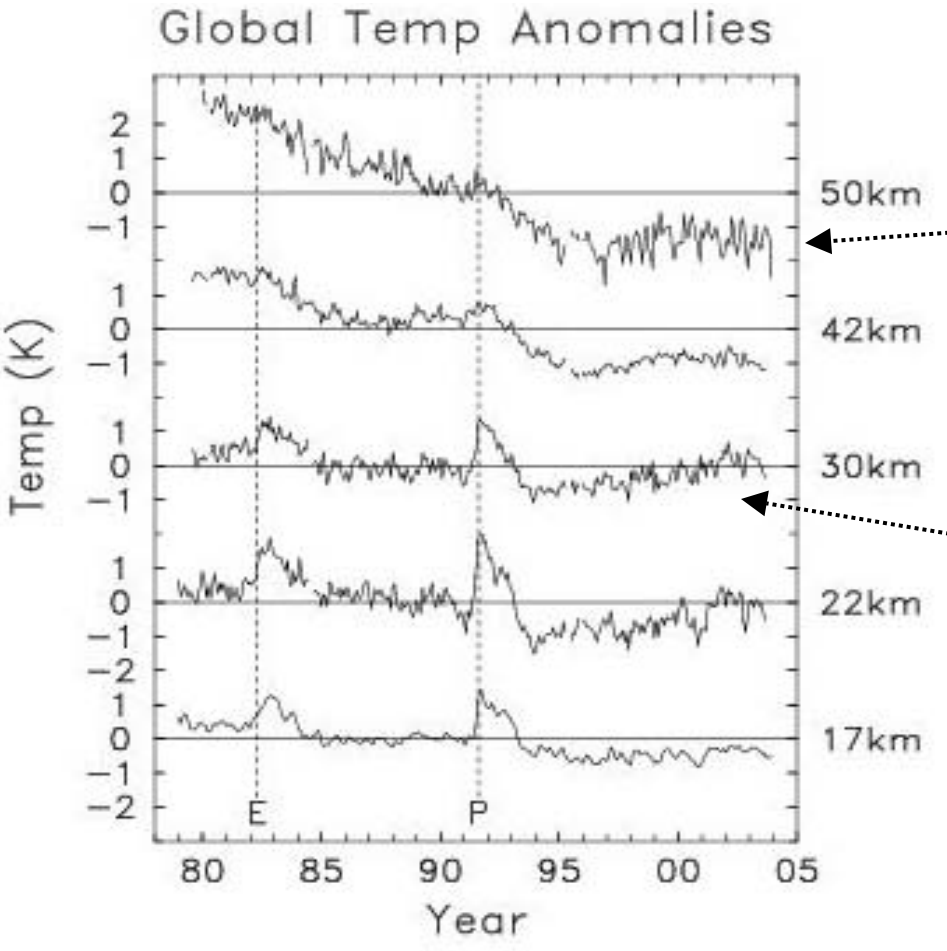


SSU: ~10-15 km thick layer temperatures





Updated stratospheric temps from SSU/MSU

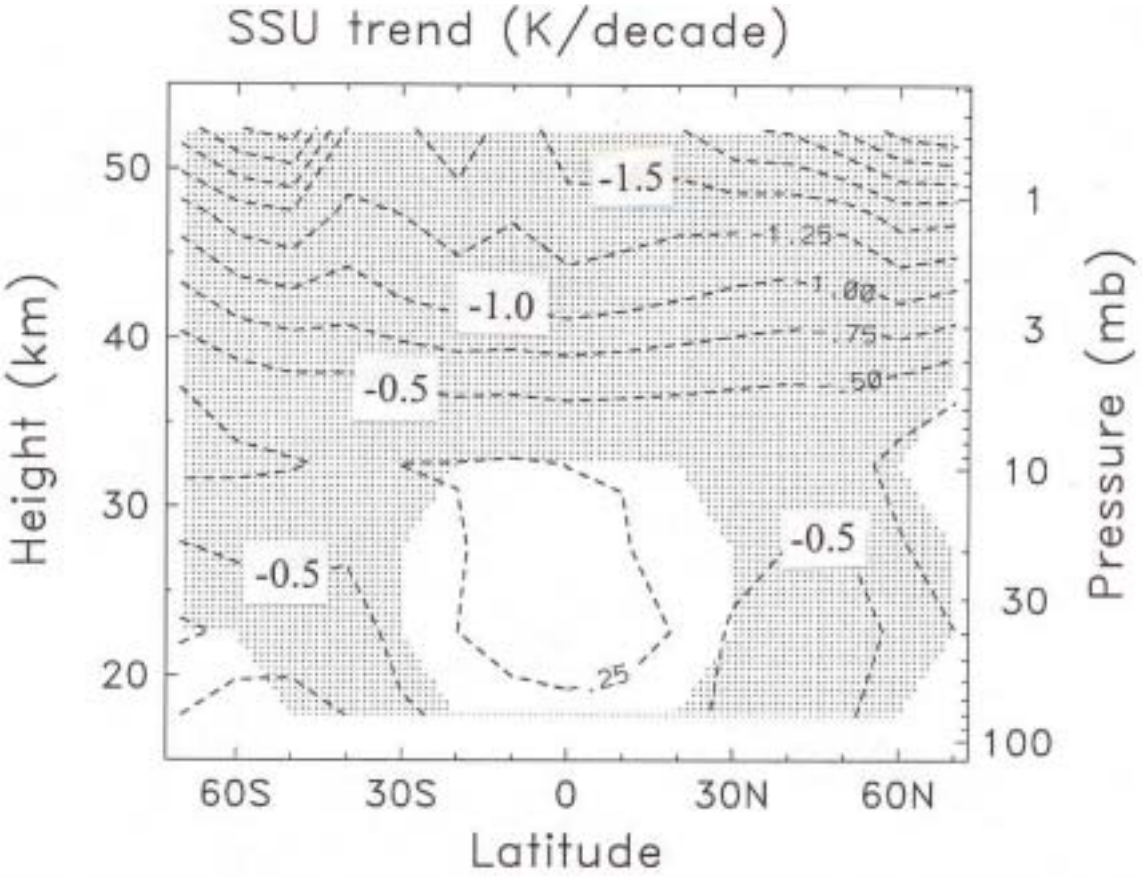


note 'flattening' of trends near stratopause

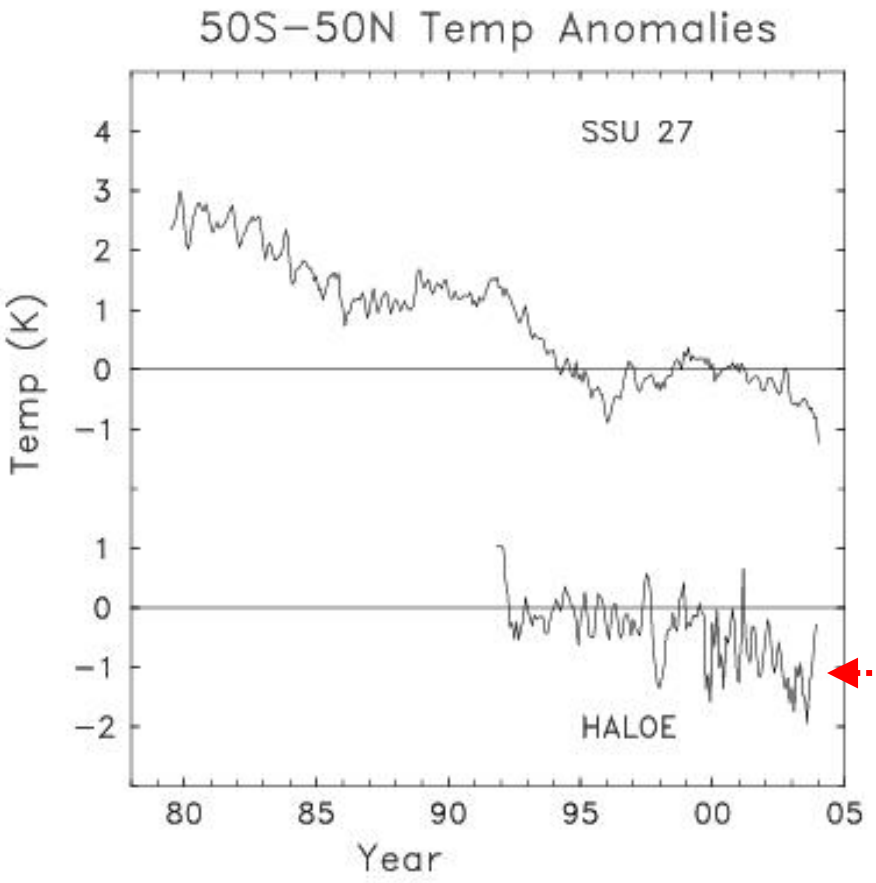
recent temp increases in lower-middle stratosphere

* Thanks to John Nash, Jim Miller, Mel Gelman and Roger Lin

Temp trends 1979-2003



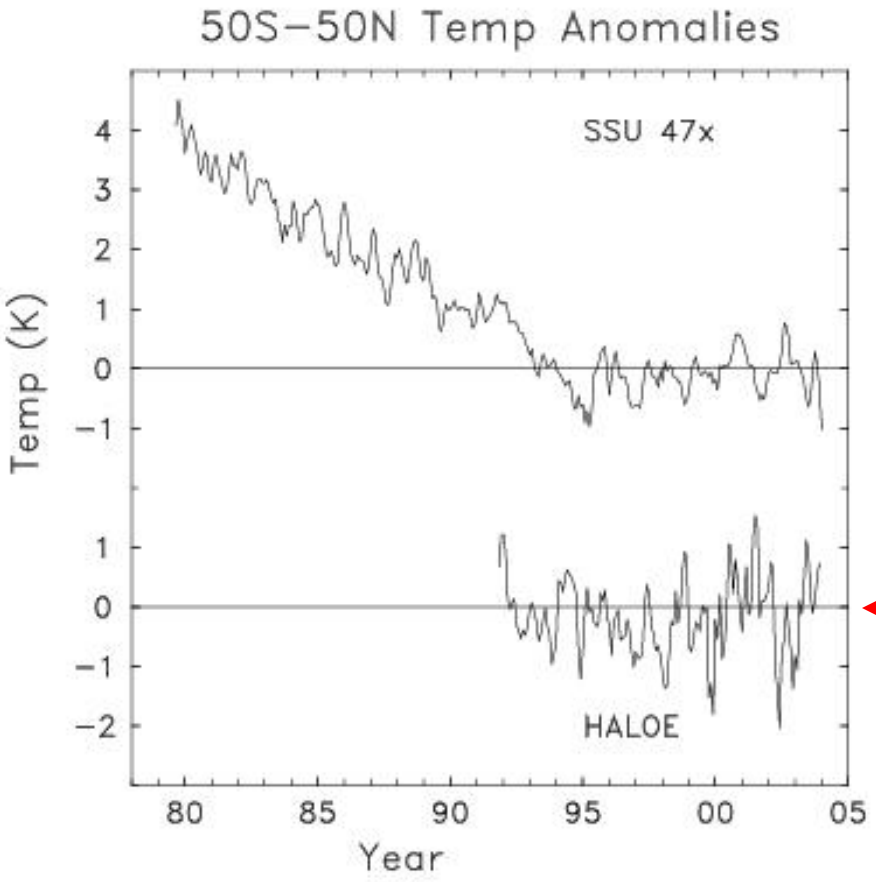
SSU vs. HALOE



SSU 27
~35-50 km

HALOE integrated to approximate SSU 27

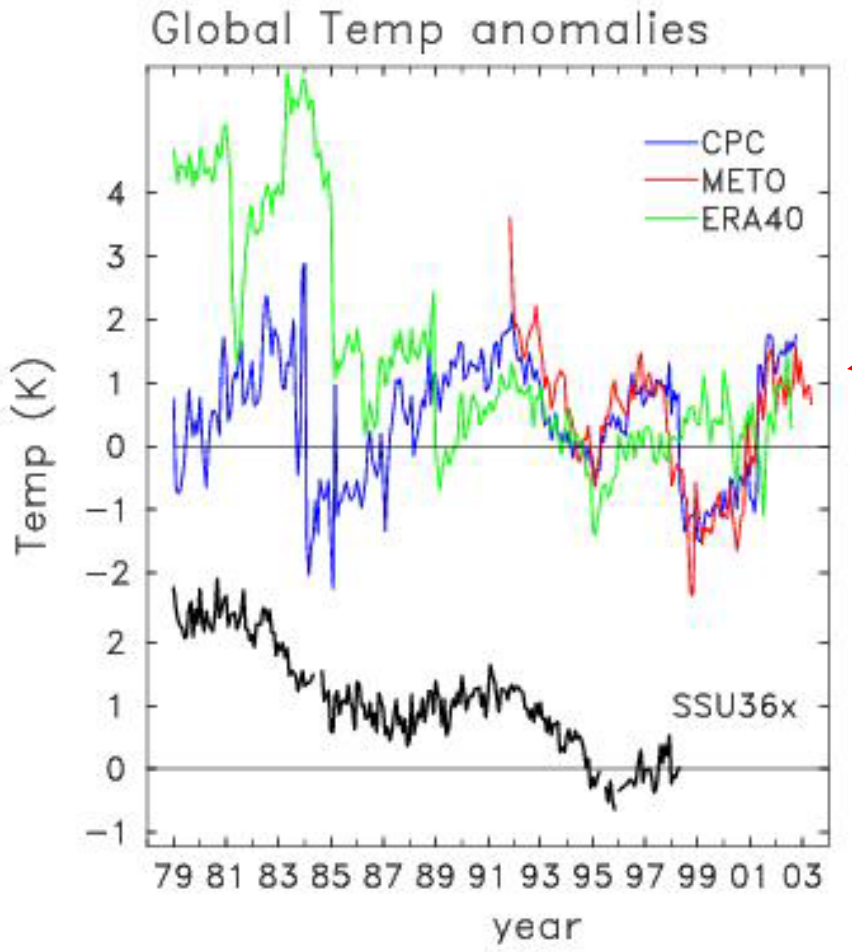
SSU vs. HALOE



SSU 47x
~43-57 km

HALOE integrated to approximate SSU 47x

Problems in operational analyses / reanalyses due to changes in satellite instruments



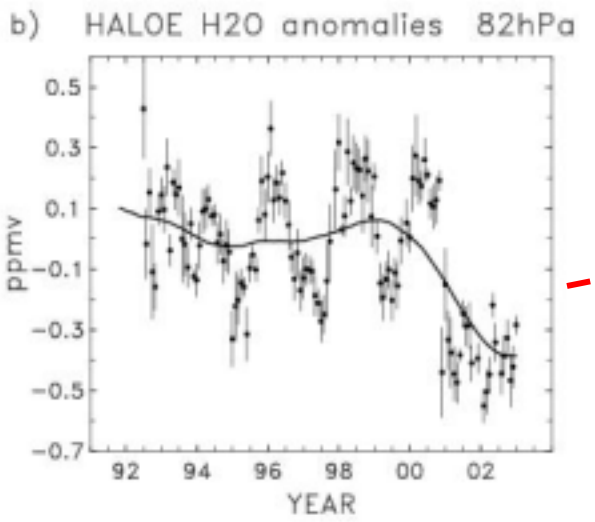
vertically integrated to approximate SSU 36x (~35-50 km)

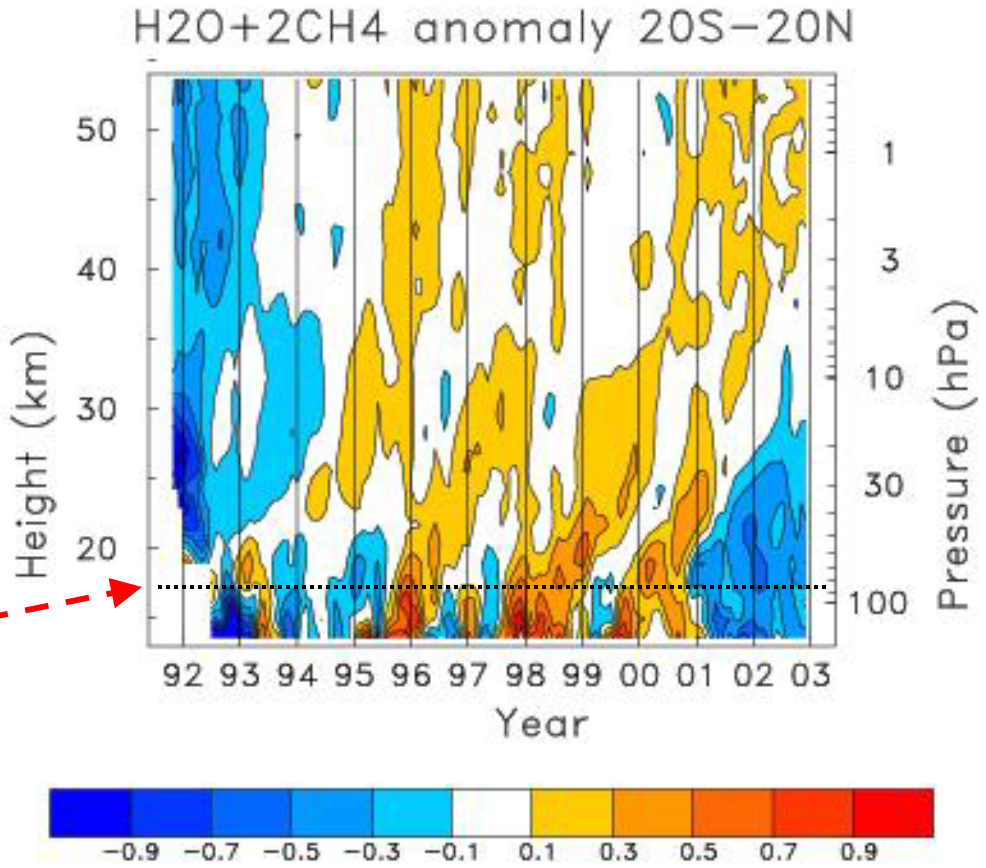
Changes in stratospheric water vapor

- HALOE global measurements for 1991-2004
- coherence with tropical tropopause temperatures
- comparison with Boulder balloon measurements

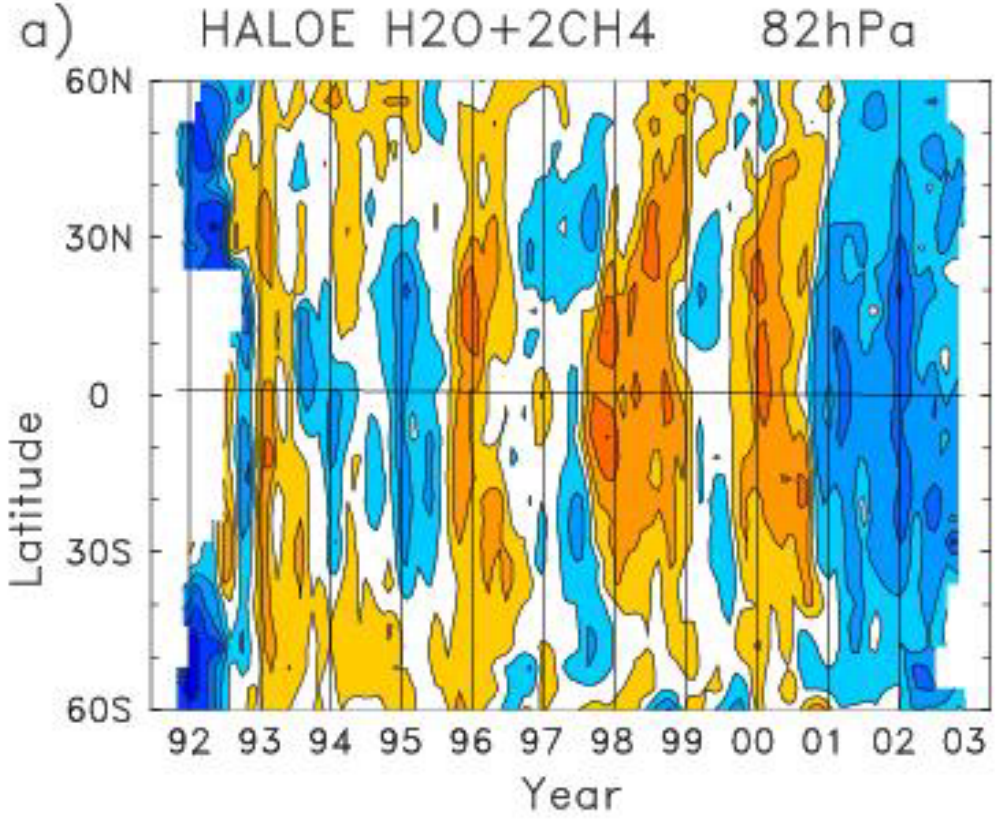
Changes in stratospheric water vapor from HALOE, 1991-2003

Deseasonalized anomalies

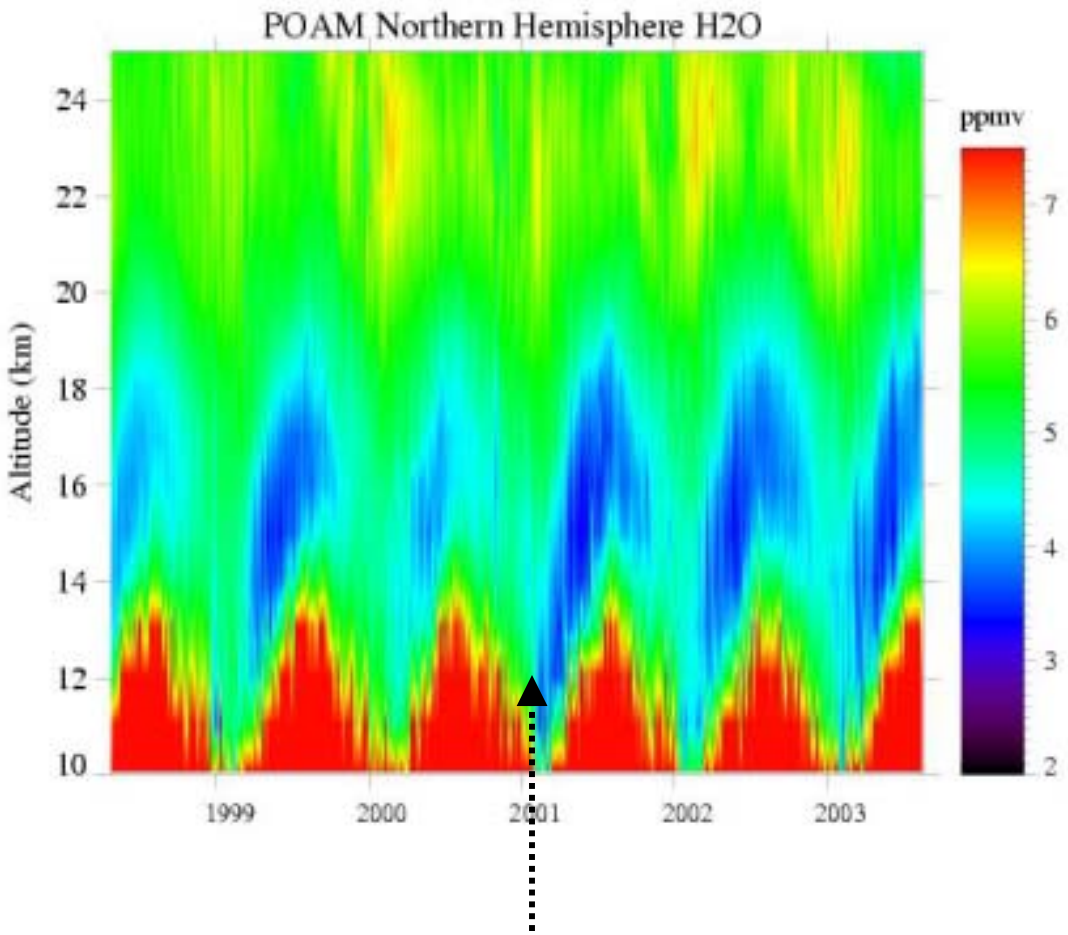




Latitude-time variations at 82 hPa

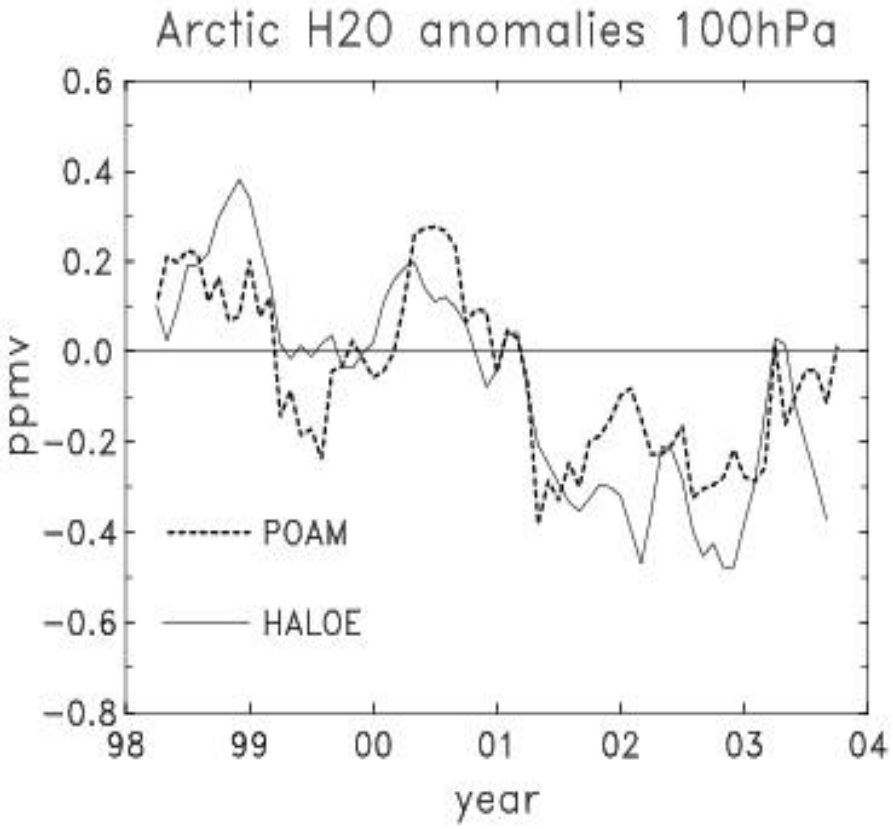


Arctic H2O measurements from POAM



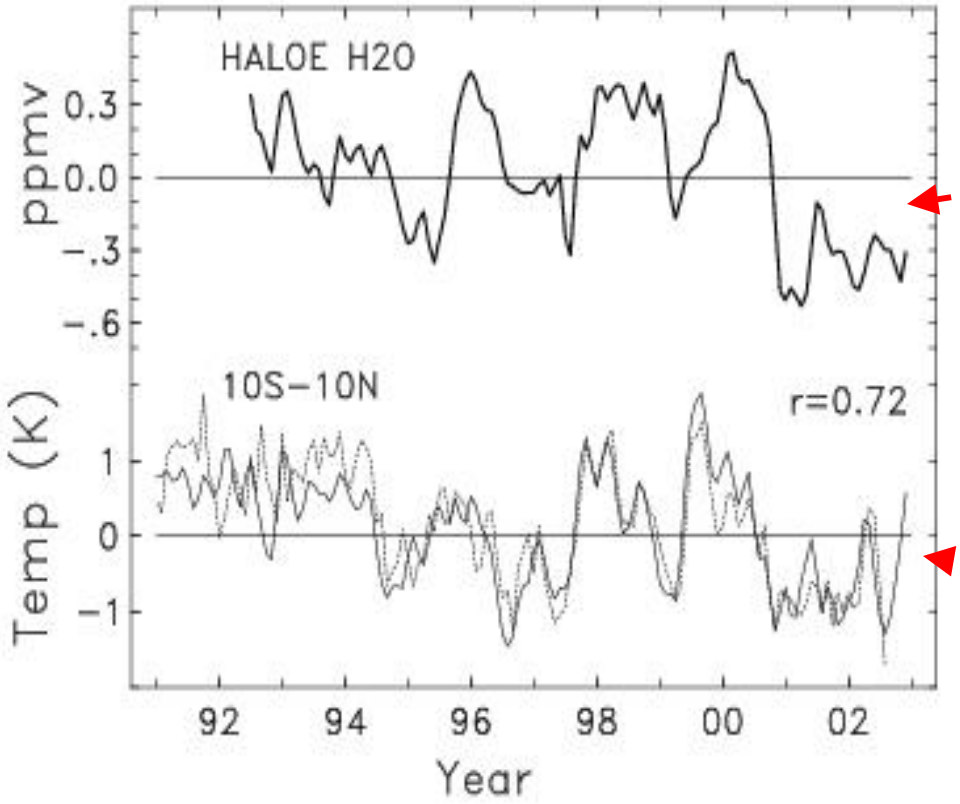
low values after 2001
consistent with HALOE

Comparison of POAM and HALOE *anomalies* 1998-2003



Remarkable agreement for changes ~ 0.2 ppmv !

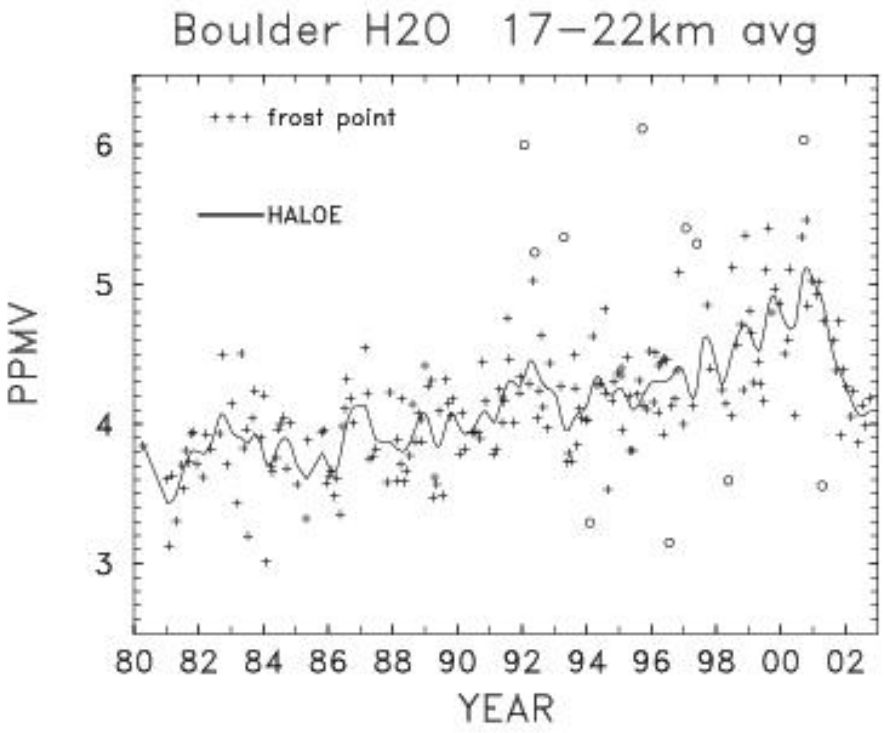
Correlations with tropical tropopause temperatures



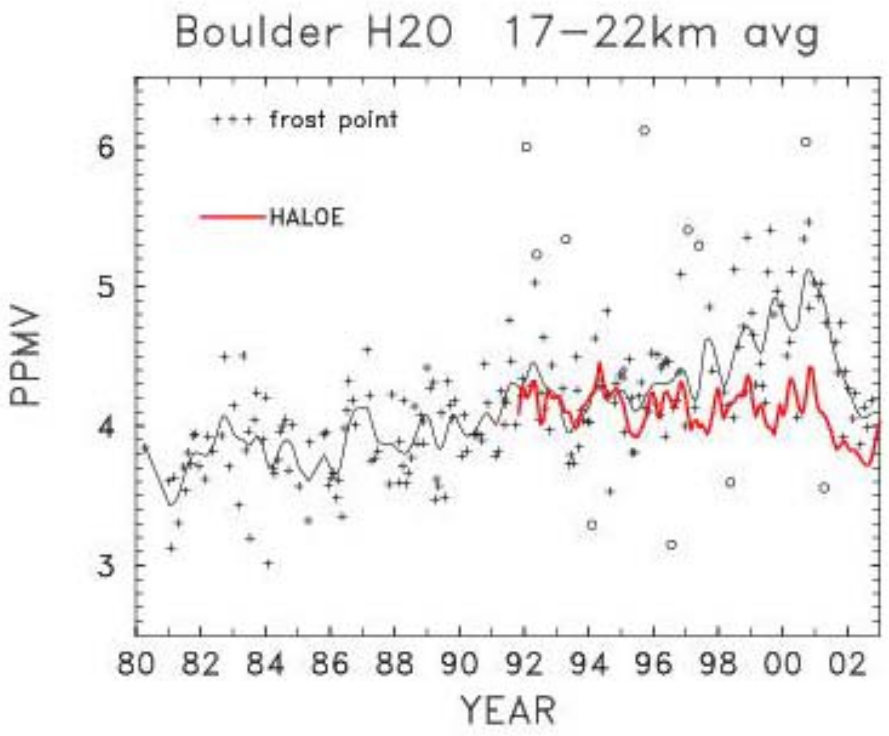
82 hPa
Water vapor
anomalies

Tropopause
temperature
anomalies

Comparisons with Boulder balloon data



Comparisons with Boulder balloon data



significant differences after 1997

The only two continuous data sets for stratospheric water vapor disagree in 'trends' for 1992-2003.

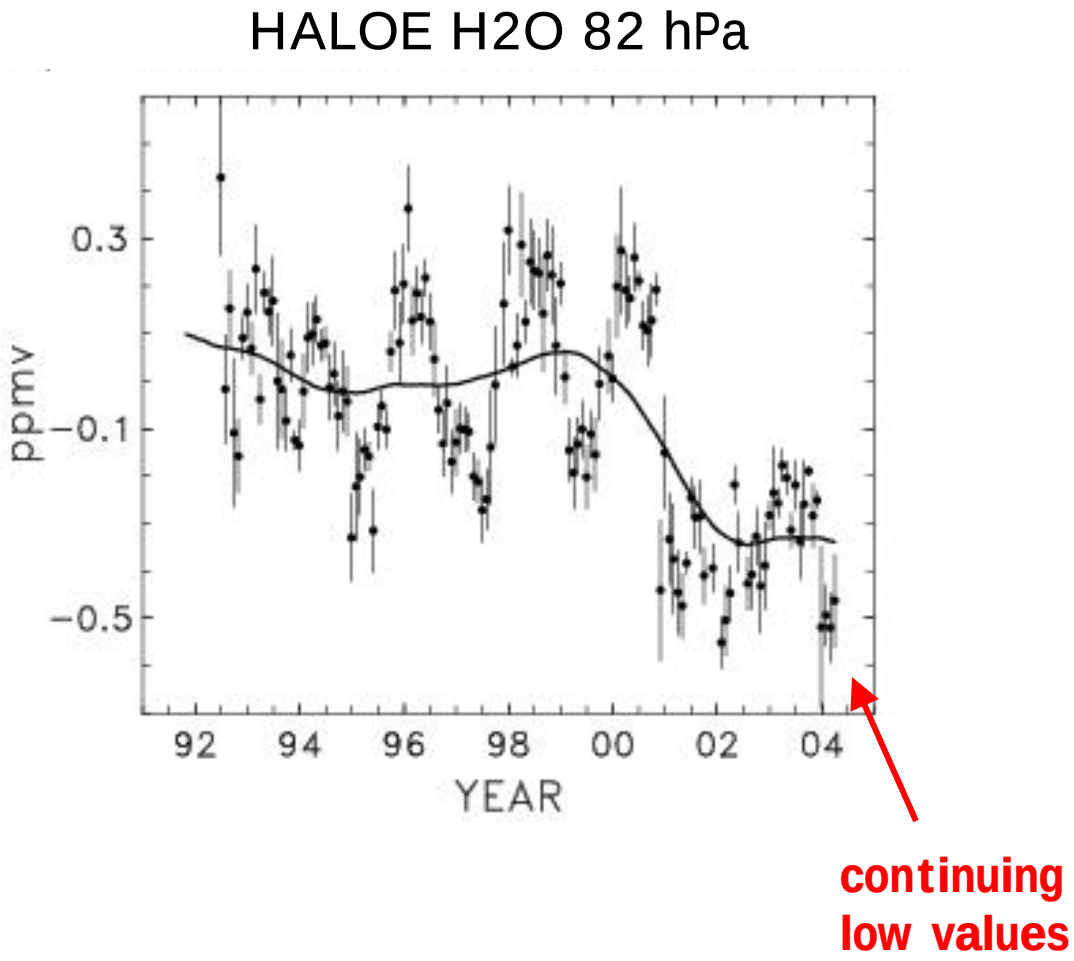
Frost-point balloon data:

* calibrated, trusted technique
* ~once-month 'snapshot' sampling

HALOE:

* calibrated, trusted technique
* global sampling
* good agreement with POAM
* internal geophysical coherence:
  - anomalies propagate in latitude/height
  - variations correlated with tropical tropopause temperatures

Most recent changes (updated to April 04)



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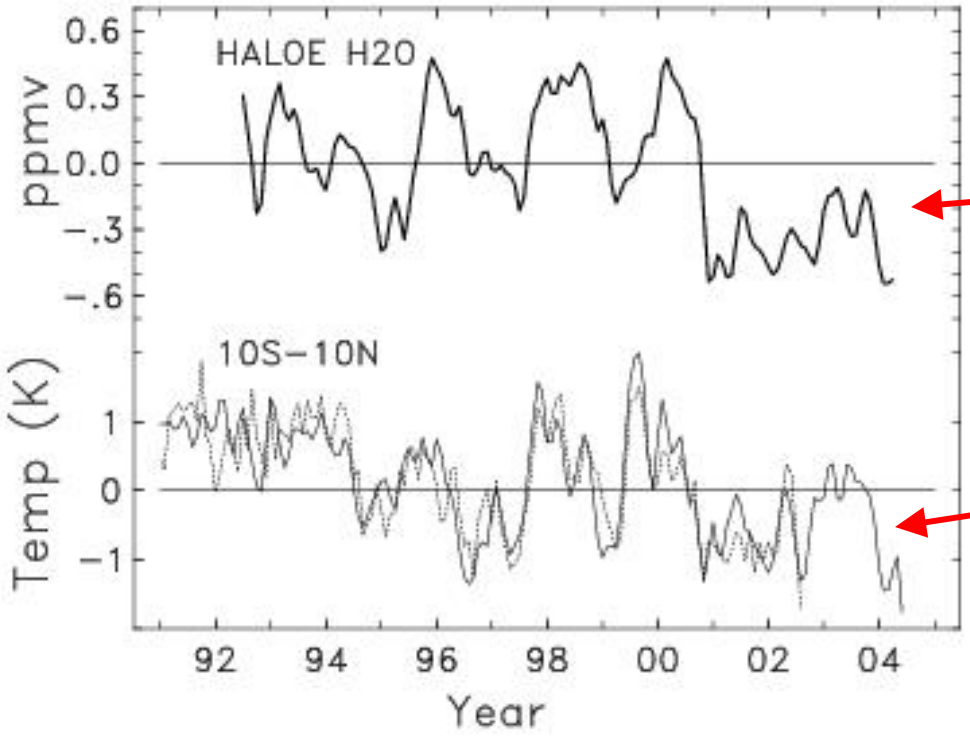
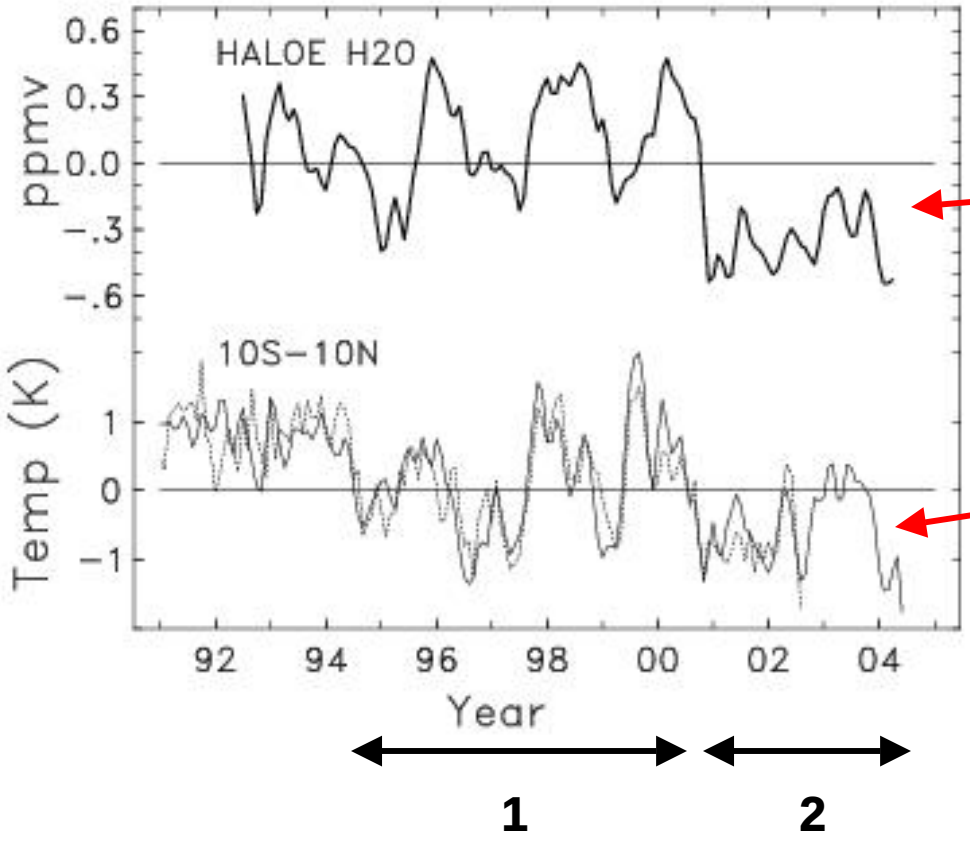


water vapor

tropopause temperatures

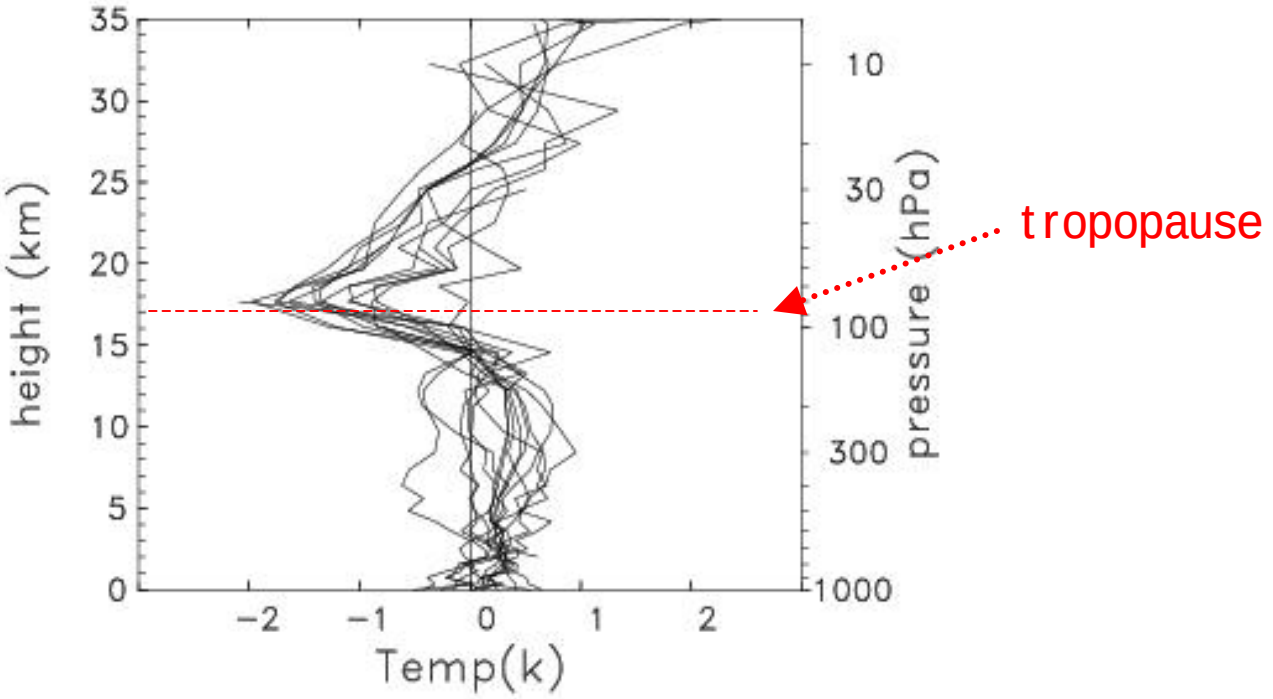
Most recent changes (updated to April 04)



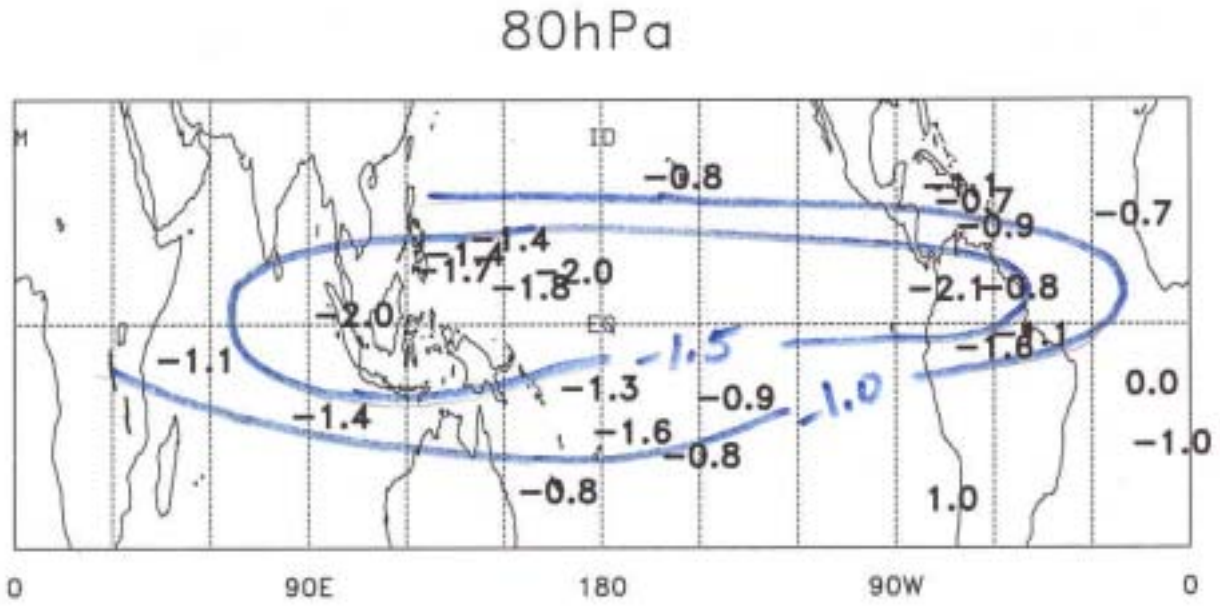
water vapor

tropopause temperatures

Vertical profile of temperature anomalies for 2001-04 (from tropical radiosondes)



Spatial pattern of temp changes: 2001-2004



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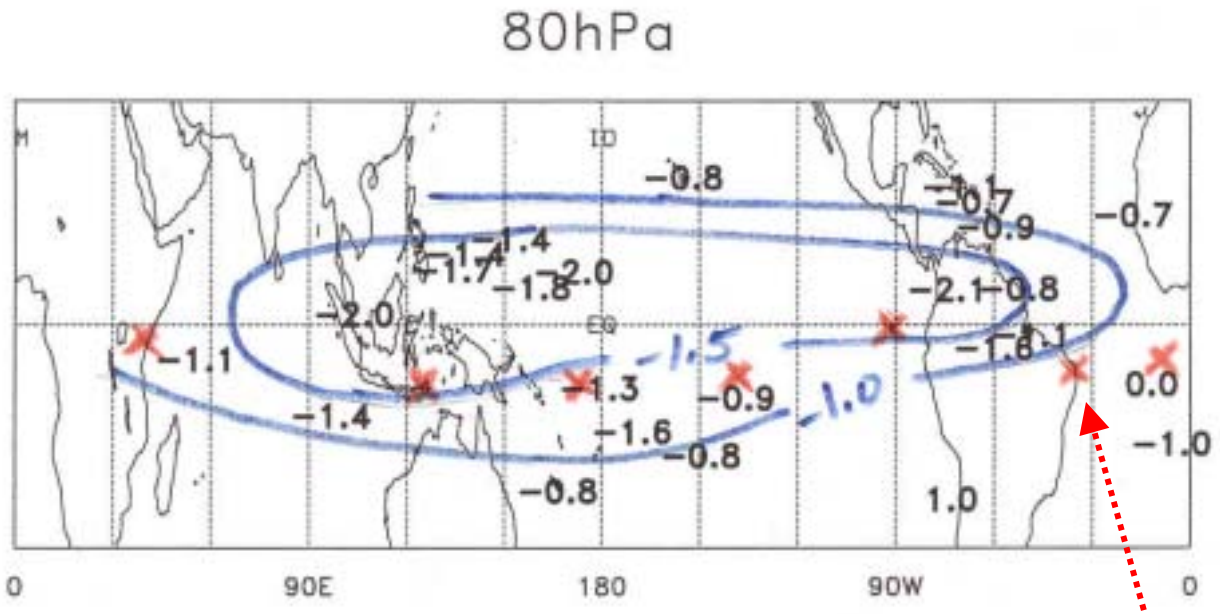
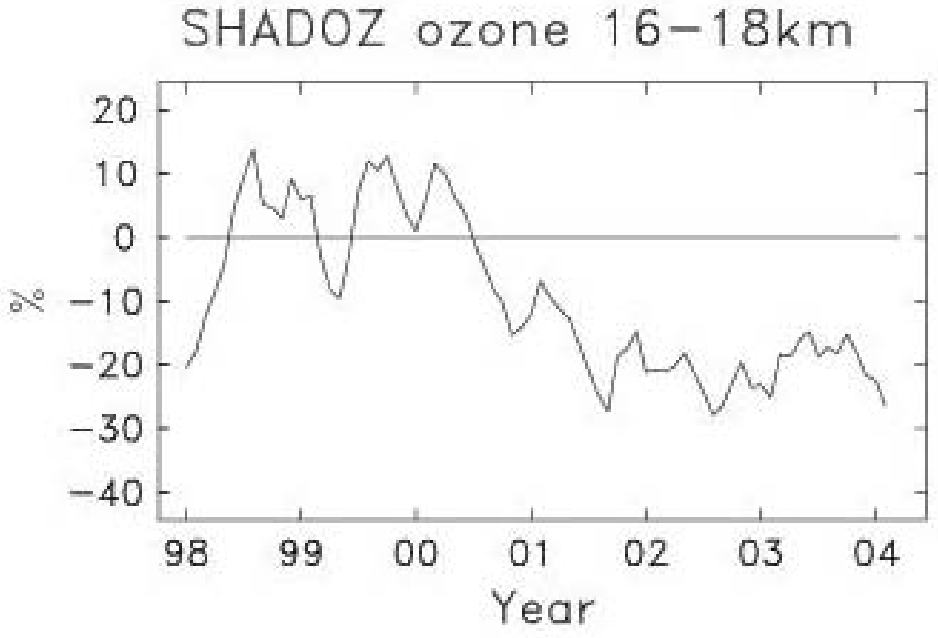
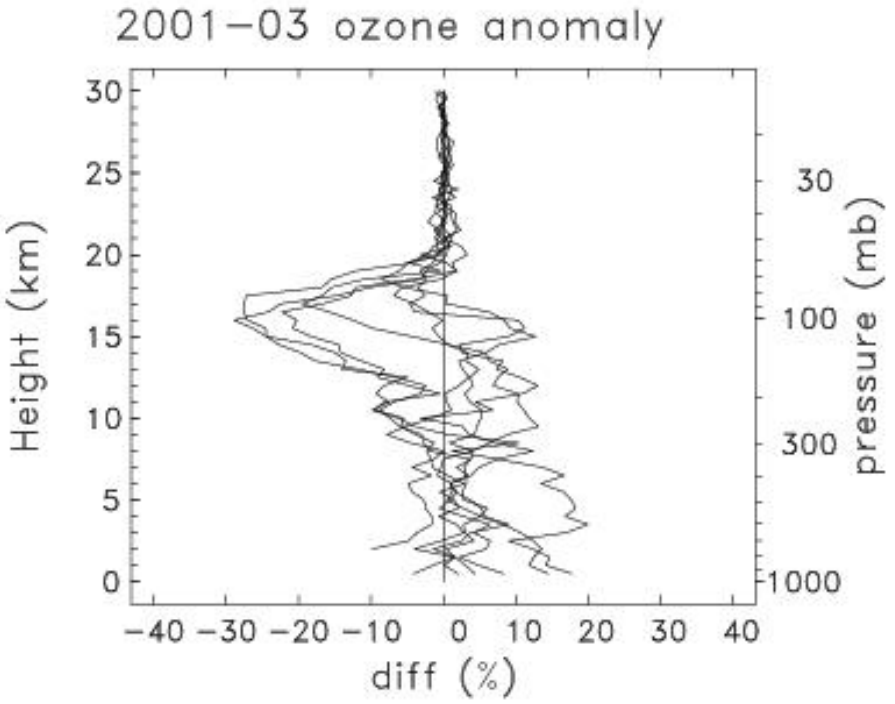


SHADOZ ozonesondes

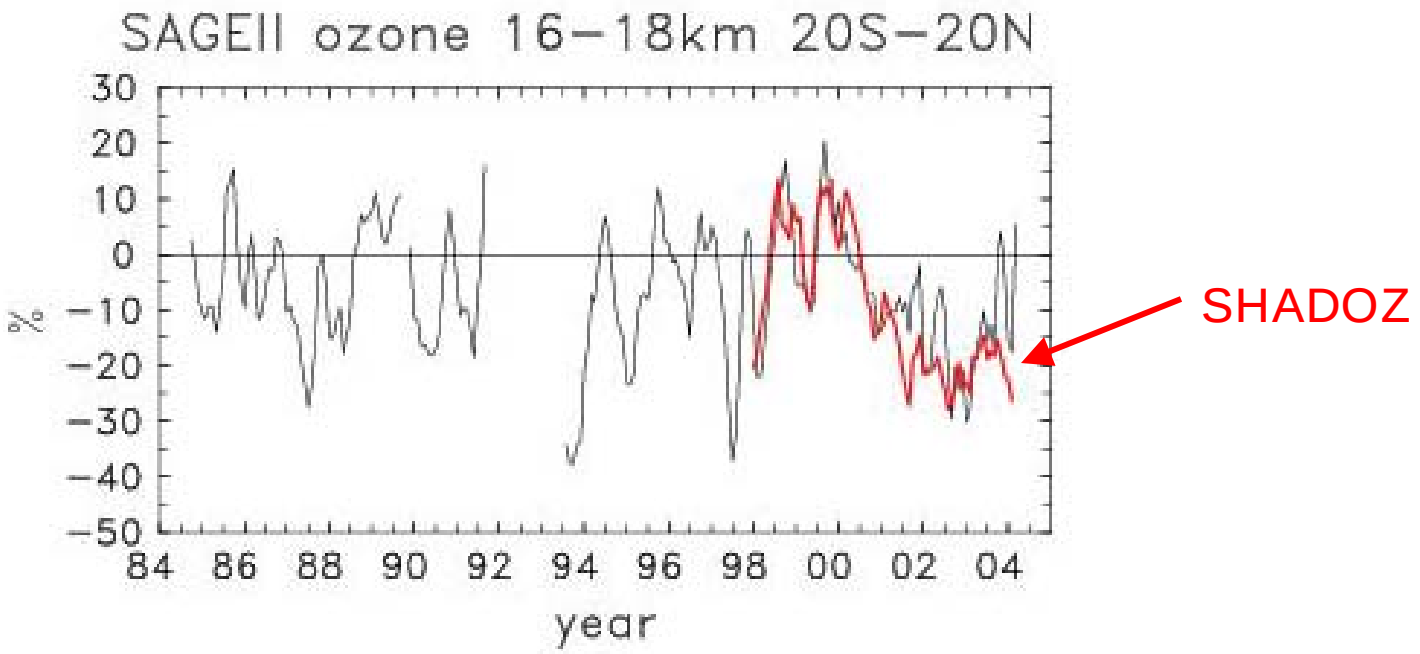
time series of SHADOZ ozone



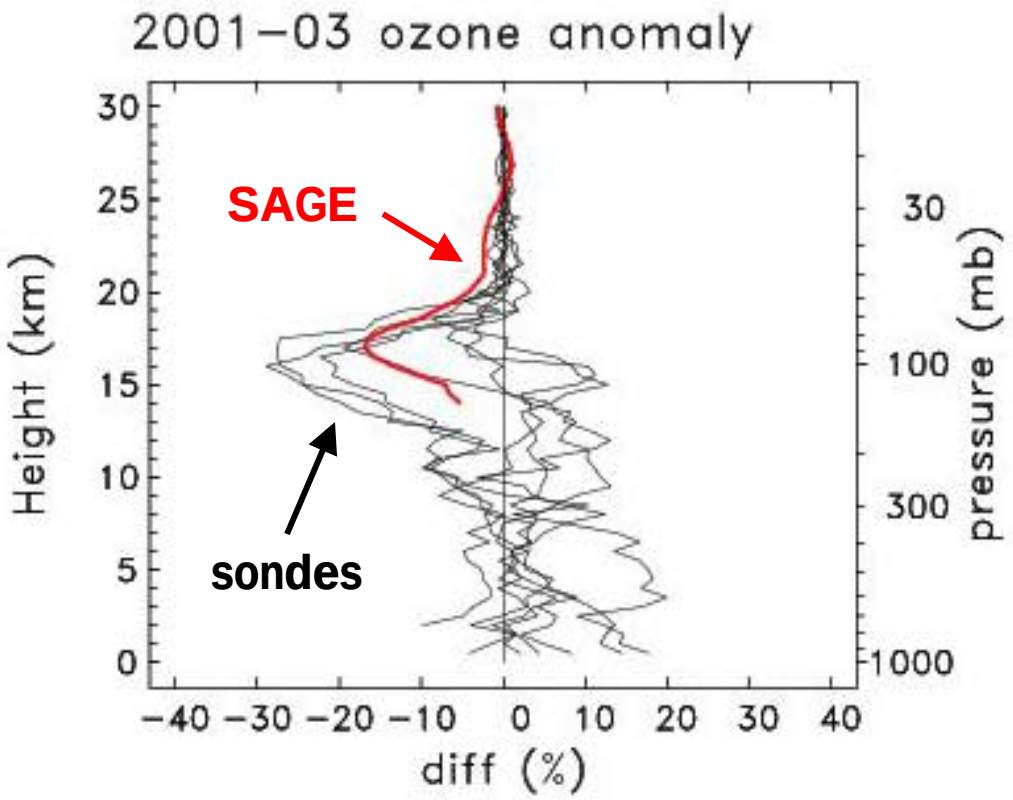
vertical profile of SHADOZ ozone changes



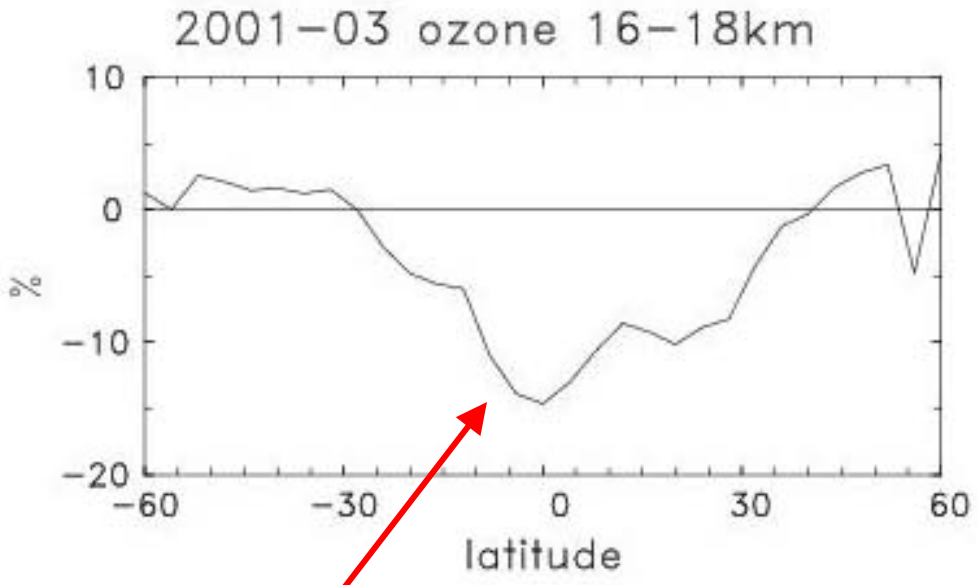
time series from SHADOZ and SAGE II



vertical profile of 2001-03 ozone changes



latitude structure from SAGE II



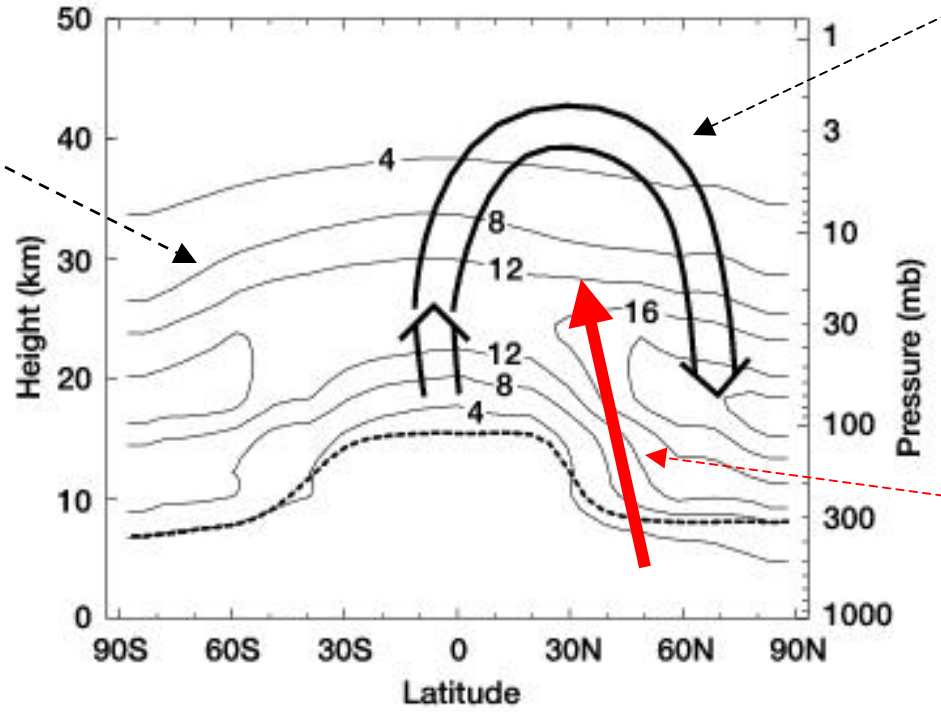
anomalies centered in tropics

Anomalous conditions near tropical tropopause during ~2001-2004

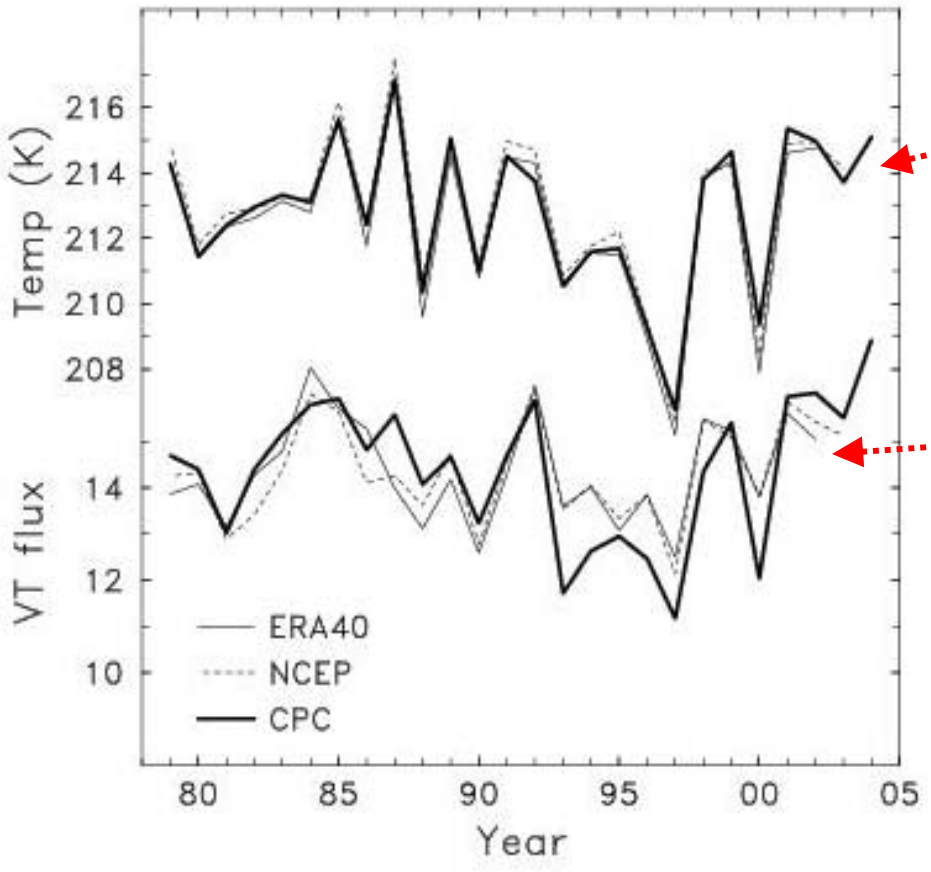
- temperatures cold by ~1-2 K

  (over narrow vertical layer, ~16-22 km)
- water vapor low (response to temperatures)
- ozone low over ~14-19 km (sondes and SAGE II)
- ozone and temperature changes centered in tropics

Changes are consistent with an increase in the tropical Brewer-Dobson circulation



Observed variations in planetary wave driving



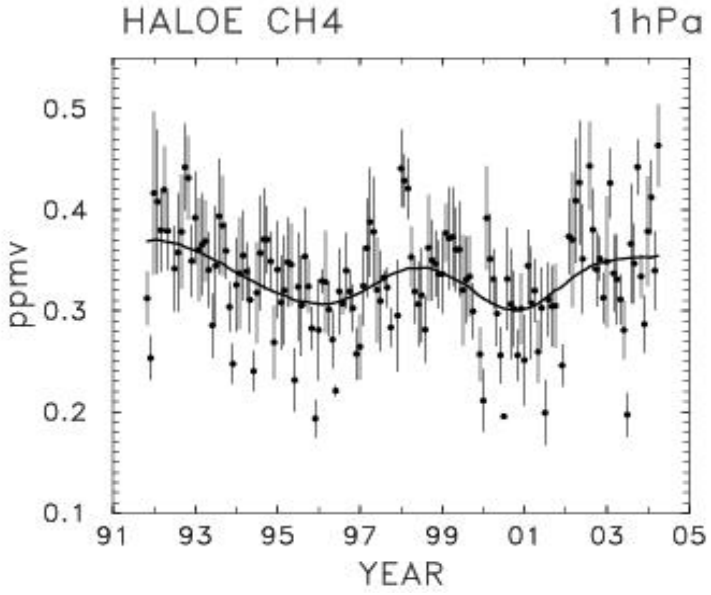
Polar temps

NH planetary wave driving

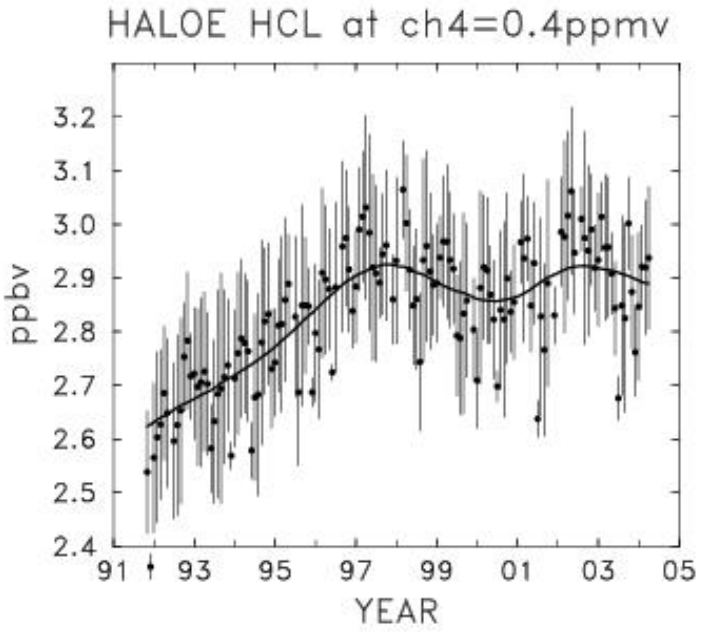
Key points:

- How do we reconcile HALOE water vapor and Boulder balloon data?
- What is causing the recent persistent changes near the tropical tropopause?
- Important to maintain satellite data records (thanks to SAGE and UARS!)

Correlated changes in CH_4 and HCl



CH_4



HCl